Available online at www.sciencedirect.com
ScienceDirect
Renewable and Sustainable Energy Reviews 13 (2009) 921–926
RENEWABLE & SUSTAINABLE ENERGY REVIEWS
www.elsevier.com/locate/rser

Capacity building strategies and policy for desalination using renewable energies in Algeria

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Received 15 January 2008; accepted 7 February 2008

Abstract

The integration of renewable resources in desalination and water purification is becoming increasingly attractive. This is justified by the fact that areas of fresh water shortages have plenty of solar energy and these technologies have low operating and maintenance costs. In this paper, an overview of capacity building strategy and policy for desalination in Algeria is presented. Importance of training and education on renewable energies is also outlined. The contribution of the Middle East Desalination Research Center in capacity building and research and development in desalination in Algeria is also presented.

Keywords: Capacity building; Renewable energy; Desalination; Education; Research

Contents

1. Introduction

Algeria has for decades relied on rainfall for the water policy and strategy, but that proved to be not an adequate solution considering the actual water deficit. The water needs for different sectors is increasing and this will worsen since it is

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1364-0321/$ – see front matter
doi:10.1016/j.rser.2008.02.001

projected that population will double in the next 20 years. The use of non-conventional solutions, mainly sea/brackish water desalination, becomes imperative and inevitable solution to supply fresh water. Many important desalination projects are launched with a target to produce about 2 million m^3/day by 2009. In this program, a dozen of large-scale seawater desalination plants using reverse osmosis technology are planned along the 1200 km Mediterranean coastline, where most of the country's population is concentrated, and several brackish water plants in other areas of the country. Desalination market is growing faster than human resources in desalination in Algeria. More efforts in training, academic education, human resources management and R&D in desalination are needed. Capacity building program is necessary not only to improve the operation and maintenance of desalination plants by enhancing human resources and expertise but also to build an integrated adoption of this sustainable technology in Algeria. Desalination technologies require thermal and/or electrical energy. Renewable energies such as solar or wind resources are suitable for small-scale desalination technologies especially in remote areas where there is no electricity supply grid.

2. Desalination

Desalination has become an imperative and inevitable solution for Algeria to overcome its current shortage of potable water. Having exploited seawater desalination largely for industrial use since the sixties, Algeria is now in a hurry to exploit this technology to quench the thirst of its citizens. The total production capacity of the operating plants in Algeria is 661,920 m^3/day. About 47% of it is produced by multistage flash (MSF) and multiple-effect distillation (MED), 44% by reverse osmosis (RO), 5.5% by vapor compression (VC) and 3% by electro-dialysis (ED) [1]. More than 67% of the total desalinated water is produced from seawater, 22% from brackish water, 8% from river water and the rest from other sources. The major user of the desalinated water is municipalities with about 49% followed by industries with 45%. The rest is by power, tourist places, military and other sectors.

The Ministry of Water Resources, through Algerienne des Eaux (ADE) and Algerian Energy Company (AEC), started recently the construction of many large-scale seawater reverse osmosis desalination plants. Among these, Hamma (Algiers), Beni-Saf, Mostaganem, Sidna Ouchaa and Honaine in Tlemcen, Cap Blanc and Tenes will supply 200,000 m^3/day each and Skikda, Douaouda, Cap Djenet will supply 100,000 m^3/day each. In order to carry out the large-scale desalination plants installed and under construction, the government approved the proposals according to BOO formula (Built, Own, and Operate) except the MSF plant constructed in the industrial zone of Arzew is in BOT (Built, Own, and Transfer) formula. This procedure will avoid risk of operation and maintenance problems due to lack of skilled manpower for the life of the plants which are estimated to be 25 years.

3. Challenge of desalination and water supply strategy

Algeria, the second largest country in Africa, is divided into four main physical regions [2]. The first region located in the north is the Mediterranean coastline of 1200 km, where most of the country's population (80%) and industry are concentrated. The second region is the Tell which extends 80–190 km inland from the coast. The next region, lying to the south and southwest is the High Plateau; a highland region of level ground together with the mountains and massifs of the Saharan Atlas of the south region. The fourth region, comprising more than 90% of the country's total area, is the great expanse of the Algerian Sahara. The water deficit caused in the coastal region will be supplied by seawater desalination and improvement of water management. All the large-scale desalination plants mentioned above are located in this region. The Ministry of Water Resources [2] targets to reduce water leakage in the network by 25%. In addition, water will be transferred from big dams to neighbor cities such as Taksebt for Algiers and MAO 'Cheliff–

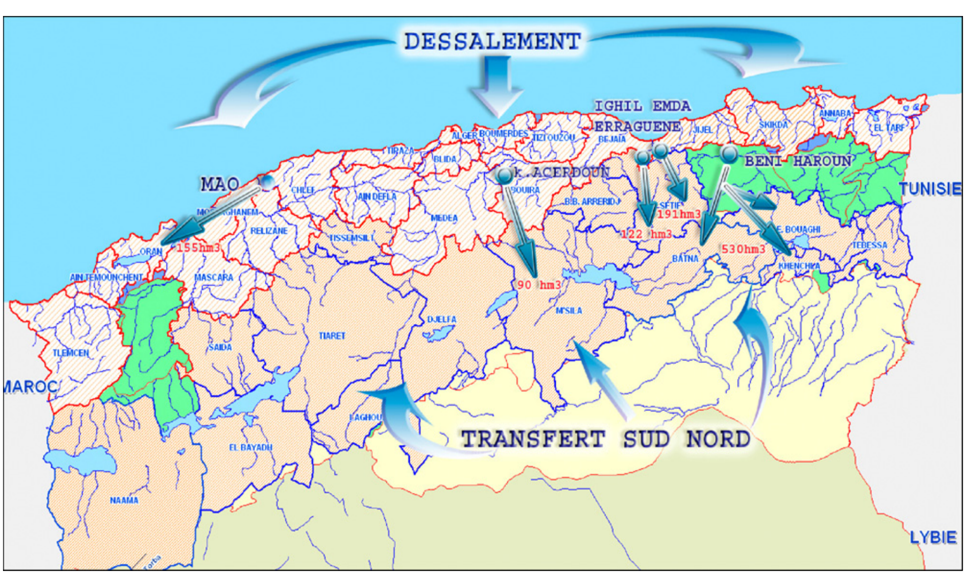


Fig. 1. Measurements planned to rectify imbalances of water in Algeria.

Mostaganem–Arzew–Oran' transfer Projects. The second region will be supplied from dams and existing wells or under construction. In order to insure the necessary resources for irrigation, the Ministry plans to transfer part of the water reserves from dams located in the north towards the Atlas Tellien, in which the surplus will be transferred towards the high plateaus (Fig. 1). The Sahara will observe one of the longest transfers by transporting water 700 km from Albian aquifer.

4. Renewable energy as energy source for desalination

Large part of the Middle East and North Africa (MENA) region is characterized by arid and semiarid environments and faces severe shortage and in some cases water bad management issues. Many countries in the region relied 100% on desalination technology such as Qatar and Kuwait. Desalination is an energy intensive process and energy requirements are huge since desalination plants are high tonnage plants. Presently, these energy requirements are met with very expensive fossil fuels which continue to increase in price and greatly contribute to global warming. It is thus an essential obligation in the future to look for alternative energy sources to meet the growing demand for desalination in MENA. Renewable energy is the most obvious choice especially solar energy since it is abundantly available in this region. However, this technology needs to be developed to reduce its limitation since it is presently at least four times more expensive than fossil fuel. Solar desalination application is feasible option for small-scale plants in remote locations where there is no grid electricity. There is growing interest to advance the use of renewable energy for desalination in MENA. However, there are very few experiences in utilizing wind and solar power, both photovoltaic and concentrated solar power, for desalination and the firms who have actual experience are mainly located outside the region. Resulting from these conditions there is a need for exchange of practical experiences in establishing desalination plants using renewable energy. Additionally there is a need for expertise about financing and market development for these facilities [3]. Algeria has high solar radiation intensity, long durations of sunshine and moderate wind speed. Therefore using these resources could benefit a wide range of people, especially those who live in rural and remote areas. Despite this, the application of renewable energy is considered modest when compared to the neighbored countries for several reasons. Some of these are

1. Algeria is a pioneer oil producer; hence decision makers believe that encouraging using renewable energy can affect oil exports.
2. Lack of well-trained instructors, technicians, textbooks and teaching aid in the area of energy.
3. Shortage of government funds for renewable energy projects constitutes an obstacle for wide utilization of renewable energy sources. In addition to the Renewable Energy Development Centre (CDER), National Oil Company established recently the New Energy Algeria (NEAL) to develop renewable energy projects [4].

4.1. Wind desalination

The coupling of wind energy and desalination systems holds great promise for increasing water supply in water scarce regions. An effective integration of these technologies will allow countries to address water shortage problems with a domestic energy source that does not produce air pollution or contribute to the global problem of climate change. Meanwhile the cost of desalination and renewable energy systems are steadily decreasing, while fuel prices are rising and fuel supplies are decreasing. Finally, the desalination units powered by renewable energy systems are uniquely suited to provide water and electricity in remote areas where water and electricity infrastructure are currently lacking [5].

4.2. Solar desalination

Many coastal and inland areas around the world have plenty of sunshine and lack fresh water supply. The logical answer to the problem is solar desalination of available seawater or brackish water. Cheap fossil fuels and the tolerated level of CO_2 accumulation in the atmosphere hindered the competitiveness of solar desalination. Today, both fuel prices and CO_2 emissions are on the rise. In the same time, both membrane-separation technology and solar electricity are gaining higher efficiency and lower cost and the competitiveness of solar desalination should be on the rise as well [6].

5. Capacity building in desalination

The urgent need for training and capacity building in desalination industry is undisputed among industry experts. Several estimates indicate that a substantial number of staff at all technical levels is needed to serve the existing and future desalination industry in MENA and in Algeria in particular. According to a 2000 study of Klaus Wangnisk for GTZ in Germany, the total training needs in the MENA region are estimated to become about 36,500 people by the year 2010.

An essential prerequisite for a well-established desalination industry is the presence of the qualified manpower particularly with regard to desalination in Algeria where there is absence of well-qualified and experienced personnel in the field of water desalination. After few years of operation, the installed small-scale desalination plants began to operate below their optimum capacities mainly due to the unavailability of skilled labors. The most important recommendation in this respect is to establish a training and education center or in the Universities to train the staff working in the sector. Desirable energy education programs should include all renewable energy sources and technologies, with particular emphasis on some specific ones depending upon the local needs and characteristics of the country. It should be flexible and allow for improvement in future. The program should be taught in an understandable language to avoid lack of knowledge and meet the needs of

large public. The program should start from primary and high school level for better acceptance and effectiveness. Energy education programs should also ensure employment of local people and the students.

5.1. Capacity building in education

Recently, training ranging from graduates University programs (MSc and PhD), short courses on desalination and renewable energy are available in Algeria. The University of Tlemcen, one of the greatest universities in Algeria, in cooperation with the Renewable Energy Development Centre (CDER), Algiers, and four other Universities implemented a postgraduate program covering aspects of renewable energy technology and its applications including in desalination. Three main specialties offered in these programs are solar applications, wind energy and biomass. Another level of training need is in desalination practice for operators, technicians and site engineers. This is totally lacking in the word and in Algeria in particular. Where available, it is limited to training on site by the supplier of the equipment when the hand over is made or by providing short training on maintenance in the supplier manufactory. Algerienne des Eaux (ADE) which own a large number of small-scale seawater and brackish water reverse osmosis plants is also offering short courses in desalination. But, this has proven ineffective in practice, seriously affecting the plant availabilities, efficiency and production cost.

5.2. Capacity building in research

There are many Algerian Universities involved in research projects on desalination, membrane technology and renewable energy. But, the main research activity remains in application due to limited funds. Considering the number of researchers and desalination growth in Algeria, there is a need for local research center such as Salt Water Conversion Corporation (SWCC) in Saudi Arabia, Kuwait Institute of Scientific Research (KISR) in Kuwait and the Middle East Desalination Research Center (MEDRC) in Oman.

6. Role of national and international institutions

6.1. Algerienne des Eaux (ADE, Algiers)

Within the bilateral cooperation between the Algerian Ministry of Water Resources and the French Ministry for Foreign Affairs, various technical assistance and training activities were entrusted to International Office for Water and carried out at ADE [7]. The program identified three components: human resources management, training of trainers and technical training courses. ADE, with a financial support provided by the Belgium Technical Cooperation (BTC), is making preparation to create an important training center for water professions in Algiers to meet a capacity building strategy and homogenization of the professional skills of the agents of the sector [7].

6.2. Renewable Energy Development Centre (CDER, Algiers)

The governmental program on Renewable Energy started in 1982 with the founding of the 'Station d'Expérimentation des Equipements Solaires—SEES'. This was transformed in 1988 to become 'Centre de Développement des Energies Renouvelables—CDER'. The new organization was given a wider remit covering all of the renewable energy sources [8].

The main goals of CDER are

- evaluating the renewable energy potential,
- development and application of solar thermal energy,
- development and application of solar photovoltaic energy,
- development and application of geothermal energy,
- development and application of wind energy,
- development and application of solar photovoltaic materials and
- development and application of solar desalination in the remote area (Sahara)

An experimental program has been conducted in the 1980s and covered the installation and testing of a significant number of solar energy projects. This program was conducted in conjunction with the local authorities of the wilayas of the southern Saharan regions. The projects were installed in remote communities and were composed of solar water heaters, PV solar pumps, PV lighting systems, solar stills as well as a small solar RO desalination plant. Most of these projects are still in operation.

6.3. Middle East Desalination Research Center (MEDRC, Sultanate of Oman)

One of MEDRC's main objectives is to promote capacity building in MENA region through training programs. To acquire and promptly enhance skills of manpower in the MENA region, various short courses on different desalination topics are needed. MEDRC started their short courses training on a regular basis in late 2003 and had since then conducted 27 courses in individual countries in MENA region in collaboration with local and international institutions, organizations, companies and governments. Among these courses four were conducted in Algeria in collaboration with local institutions. 172 Algerian participants (operators, engineers, consultants, designers, managers, researchers and policy makers) were selected from a large number of applications to attend the four courses conducted in Algeria and 17 other Algerian participants were invited to attend advanced courses conducted in Bahrain, Egypt, Oman and Tunisia. Details of the courses conducted in Algeria are presented in Table 1. MEDRC has also funded a research project to an Algerian researcher with a PhD scholarship to an Algerian student from Blida University. The principal investigator of this project is from Angers University in France.

MEDRC is also providing technical assistance to Universities and specialist dealing with desalination and is prepared to

Table 1
MEDRC courses conducted in Algeria [9]

Date/place	Title	Instructors	Co-organizer/co-sponsor	Participants
June 25–28, 2006, Algiers, Algeria	Thermal Seawater Desalination Technologies	Prof. Mohamed Darwish (Kuwait), Mr. Alain Maurel (France) and Dr. Wahib Naceur (Algeria)	Conservatoire National des Formations à l'Environnement (CNFE), Algeria	29 Algerian participants from 21 establishments
March 18–21, 2006, Bejaia, Algeria	Fundamentals, Design and Applications of RO Membrane Desalination	Mrs. Sophie Bertrand (France), Mr. Kamel Fethi (Tunisia), Prof. Safia Taleb (Algeria) and Dr. Noreddine Ghaffour (Oman)	Bejaia University, Algeria	48 participants from 25 establishments, Algeria (44) Tunisia (4)
May 29–31, 2005, Arzew, Algeria	Seawater & Brackish Water Desalination Technologies: RO & Thermal Processes, Principle – State of the Art – Comparison	Mr. Alain Maurel (France) and Dr. Noreddine Ghaffour (Oman)	Sonatrach (Algerian National Oil Company), Algeria	55 Algerian participants from 37 establishments
December 11–15, 2004, Algiers, Algeria	Membrane Techniques for Brackish & Seawater Desalination: Principles—State of the Art	Mr. Alain Maurel (France), Prof. Michel Rumeau (France) and Dr. Jean-Christophe Schrotter (France)	Centre de Développement des Energies Renouvelables (CDER), Algeria	45 participants from 30 establishments, Algeria (44) France (1)

provide assistance to universities who are willing to implement courses and degrees in desalination. In addition the scholarship program can produce specialist who can work at these universities upon their completion of their study abroad.

6.4. Mediterranean Renewable Energy Program (MEDREP)

It offers to the Mediterranean countries an ambitious program, based in three principal objectives [10]:

- Provide modern energy services particularly to rural populations.
- Contribute to the climate change mitigation by increasing the share of renewable energy technologies in the energy mix in the region.
- Capacity-building and technology transfer.

MEDREP proposes many arrangements for capacity-building and technology transfer:

- human resources development/training,
- education/building awareness,
- institutional strengthening, including local participation,
- technology transfer/exchange and
- enlargement of the area benefiting of MEDREP Pilot Projects to all the other countries of the Northern African region and other Mediterranean countries.

6.5. Other institutions

Station d'Experimentation des Experiments Solaires en Milieu Saharien in Adrar and Renewable Energy Department Laboratory of University of Ourgla are conducting research in the areas of application of renewable energy in desalination and in particular solar still [11]. The University of Chlef in Algeria and Sultan Qaboos University, Sultanate of Oman, are carrying out a research project related to a solar seawater greenhouse desalination unit, implanted at AL-HAIL site in Muscat [12]. Many other Universities are carrying out research projects in the area of desalination mainly in RO process.

7. Conclusion

The use of renewable energy for desalination appears nowadays as a reasonable and technically possible option towards the emerging and stressing energy and water problems. However, and despite intensive research world-wide, the actual application of renewable energies in desalination industry is very low due to many limitations. In Algeria, education and training programs on renewable energy ranging from undergraduate university to specialized postgraduate are available. Numerous short courses, workshops and seminars focusing on desalination and specific aspects of membrane technology were organized to improve the existing individual and group skills. Different local and international organizations and institutions are providing technical programs in different levels but is it still too low to meet the actual and future human resources needs in desalination. Considering the huge desalination program launched by the Algerian Government in a short period of time, capacity building is urgently needed at both the undergraduate and postgraduate levels in addition to the implementation of a new water management strategy.

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